STEP 2 BUILDING THE ADC CIRCUIT

CIRCUIT DESIGN AND CONSTRUCTION

Your goal is to build a free-running analog to digital converter similar to that in Figure 17 on the ADC0804 data sheet. The ADC0804 is designed so that it can be used on a computer bus. This means that its digital output pins are in a high-impedance state unless the RD (read) pin is pulled low. Also, the chip is disabled unless the CS (chip select) pin is pulled low. For static tests, we simply ground both pins. If CS is low, and the chip is active, a low pulse on the WR (write) pin causes a conversion to begin. When the conversion is finished, a low level appears on the INTR (interrupt request) pin to signal the fact. It does not have to cause an interrupt, but can merely be sampled to find out the converter status. If we connect INTR to WR, the end of each conversion will begin a new one, and the converter will always display the latest data at its output. In figure 17 of the data sheet, the capacitor C between pin 4 and ground and the resistor R between pin 4 and pin 19 create an RC oscillator using an internal inverter with hysteresis. The values of R and C decide the clock frequency. Eight clock pulses are used for each bit for a total of 64 clock pulses required to finish one conversion, plus a variable delay of up to 8 clock pulses when a conversion is initiated. Therefore one conversion can take about 70-72 external clock pulses, see the data sheet of the ADC0804 for the exact number. The slower the clock, the longer a conversion takes.

An external clock signal can be fed to pin 4 instead of using the internal oscillator. In this case, the resistor R between pin 4 and 19 is not used, and pin 19 is left open.

First you must make some design decisions.

SET-UP THE ADC CLOCK

See Figure 5 on the data sheet. f_{CLK} vs Clock Capacitor in the Harris ADC0804 datasheet or use the formula:

$$\frac{1}{2RC} < f_{CLK} < \frac{1}{1.1RC}$$

APPROPRIATE VALUES OF R AND C

- Considerations
  - What are the capabilities/limitations of the chosen ADC chip? How many samples/second can it measure?
  - What is the maximum frequency you want to measure?

- How often do you want to sample the signal? How does this compare to the ADC capability? A design compromise may be required here.
- How many internal clock pulses are required to make a measurement?

➢ Choose values for R and C for your timing circuit.

➢ Before installing the timing circuit and testing the ADC, see design notes below.

➢ Observe the ADC Pin 4 voltage on the scope to verify the clock frequency

➢ Use LED's to check for functionality and accuracy (Figure 18, ADC0804 data sheet) – see Design Note 2 below.

➢ Take data for at least 15 dc input voltages over the span of 0 to 5 V. What is the voltage resolution of the ADC?

➢ Generate a result table: dc input voltage, ADC output (binary bits), hex word, calculated output voltage

$$V_{out} = \left(\frac{MS}{16} + \frac{LS}{256}\right) \times 5.12\,V$$

where MS represents the digital equivalent of the four most significant bits (or hex character), and LS represents the digital equivalent of the four least significant bits (or hex character)
These calculations can be done in Excel using the hex2dec function.

DESIGN NOTE 1: The timing circuit formed by R and C can be installed on the 6 pin socket, in the top left corner of your printed circuit board, PCB. You can trace the connections on the PCB to determine which pins of the 6 pin socket are connected to pin 4 and 19 of the A/D, you may confirm the connections by using the digital voltmeter to measure the resistance or potential difference or use the continuity check.

ADC chip	6 pin timing socket
Pin 4	Pin 1 or pin 5
Pin 19	Pin 6
Pin 10 = DGND	Pin 2

DESIGN NOTE 2: Remember that the LED's are indicating Active Low logic. A lit LED represents a logic 0. The ADC is sinking current from the 5 V supply through a resistor and LED.

DESIGN NOTE 3 : Take a look at figure 17 on the ADC data sheet. Pins 1(CS_) and 2 (RD_) need to be connected to ground. Pins 3 (WR_) and 5 (INTR_) also need to be connected together. You can add a wire to pin 3 or 5 that can touch ground when needed to reset the ADC. All of these pins, as well as ground, are available in the connector row on the PCB board.

The other connection you need is from GND to Vin-. This establishes a common ground. These pins are on the lower edge of the board.

DESIGN NOTE 4: In the next steps, we'll need to input a ramp or a sinusoidal signal to the A/D, It's very important to follow the following instructions.

- A negative input voltage or an input above 5V could destroy the chip so make sure the signal goes from +0 to +5V only.
- You must always use the scope to verify the signal levels first.
- Always remember to change output Impedance of the HP Function Generator from 50 ohms to high Z.

  HOW TO CHANGE THE OUTPUT IMPEDANCE OF THE HP FUNCTION GENERATOR

  1. Press Shift and then Enter to enter the system menu.
  2. Press the Right Arrow until Sys Menu is displayed
  3. Press the Down Arrow until you see 50 OHM or High Z on the display.
  4. Press the Right Arrow to change from 50 OHM to High Z.
  5. Press Enter to exit from the system menu.
- Apply the supply voltage before applying the signal.
- Remove the signal before removing the supply.

INTRODUCE THE HP54645D LOGIC ANALYZER

- Observe ADC output bus (bits 7..0) on analyzer channels 0 to 7 for a ramp input (0 to 5 V ramp, 10 Hz frequency). Can you observe the binary count from 0 to 255?
- Add an analyzer connection (channel 8) to the $\overline{\text{INTR}}$ pin, Pin 5 of the ADC0804
- Use the cursors to measure the period between pulses on the $\overline{\text{INTR}}$ pin. How many internal clock cycles does this period represent? Use your measurements of the pin 4 waveform to get your answer. How does this number of clock cycles match with data sheet specifications?
- Save your analyzer data bus display setup to disk for later use.

DELIVERABLES

VERIFICATION:

Have your TA confirm the functionality of your circuit. You will be graded on output and construction quality.

REPORT:

- Show your design goal for the ADC internal clock frequency and the calculations of the required values of R and C.
- Report on the measured clock frequency (pin 4) and compare it to your design goal.
- Include your result table from the dc measurements. Comment on the accuracy and resolution of the ADC.
- Report on the logic analyzer measurements.

DESIGN NOTE: Try to standardize on a color scheme for your wiring. For example, red for power, white for ground, blue for signals. This technique makes debugging a little easier.